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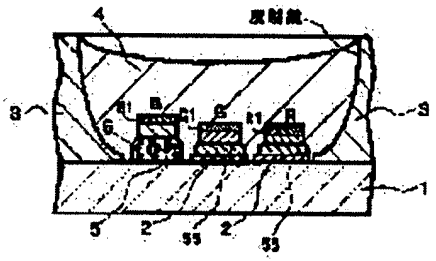
(54) LED DISPLAY



(57)Abstract:

PURPOSE: To improve the external quantum efficiency of a blue LED chip, in the realization of a full-color LED display using the blue LED chips each of which comprises gallium nitride based compound semiconductors.

CONSTITUTION: On a printed circuit board 1 on whose surface a conductor layer 2 is formed, at least, blue, green and red LED chips B, G, R are mounted, and the whole of the three LED chips is molded, and thereby, one picture element of an LED display is formed. The blue LED chip comprises a gallium nitride based compound semiconductor LED chip wherein on a sapphire substrate gallium nitride based compound semiconductors are laminated. Further, the sapphire substrate of the gallium nitride based compound semiconductor chip is bonded to the printed circuit board 1 via a transparent or white insulation bonding agant

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[Claim(s)]

[Claim 1] On the printed circuit board by which the conductor layer was formed in the front face, at least A blue LED chip, In the LED display with which the green LED chip and the red LED chip were laid, the mold of these whole LED chip was carried out, and 1 pixel was constituted Said blue LED chip consists of a gallium nitride system compound semiconductor LED chip with which the laminating of the gallium nitride system compound semiconductor was carried out on silicon on sapphire. The LED display characterized by furthermore the silicon on sapphire and said printed circuit board of said gallium nitride system compound semiconductor chip having pasted up through transparence or white insulating adhesives.

[Claim 2] The LED display according to claim 1 characterized by mixing in said insulating adhesives the insulating filler in which the reflection factor in a 360nm - 500nm wavelength region has 60% or more.

[Claim 3] The LED display according to claim 1 characterized by the reflection factor in the 360nm - 500nm wavelength region of the printed circuit board side in which said blue LED chip is laid being 60% or more.

[Claim 4] It is a LED display given in any 1 term of claim 1 characterized by adjusting the height of the light-emitting part of said blue LED chip to the location [at least] higher than the light-emitting part of a red LED chip, and adjusting the height with the thickness of said insulating adhesives thru/or claim 3.

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to a display equipped with the blue LED chip with which the full color LED display with which it comes to lay blue, green, and a red LED (light emitting diode) chip on a printed circuit board was started, especially the laminating of the gallium nitride system compound semiconductor was carried out on silicon on sapphire.

[0002]

[Description of the Prior Art] LED is used for flat-surface mold displays, such as a signboard and an ad pillar. It divides roughly into a LED display and what arranged in on a flat surface LED which carried out mold by resin, and the thing which laid the LED chip on the substrate, connected the electrode, and carried out mold by resin from on the are known. Since the latter LED display can constitute 1 pixel small and the screen where resolution is high can be realized also in it, much is expected in the future.

[0003] In the latter LED display, the printed circuit board by which the conductor

layer was printed is used for the substrate in which an LED chip is generally laid. There are a laminated circuit board which carried out the laminating of the substrate with which the conductor layer was formed in the front face of the ceramic substrate called a green sheet, and a substrate with which the conductor layer was printed by the single insulating substrate in the printed circuit board. An LED chip is laid on these printed circuit boards, and forward [of an LED chip] and a negative electrode are electrically connected to the surface conductor layer, respectively.

[0004] The type section Fig. which expresses the 1-pixel structure of the conventional LED display to drawing 5 is shown. It is the conductor layer to which 1 was used as the printed circuit board and pattern formation of 2 was carried out on the surface of the printed circuit board. The paste of W, Ag, etc. is printed, Au plating is performed and the conductor layer 2 is formed in order to raise an adhesive property with an LED chip from on the. 1 pixel of a LED display is conventionally constituted by connecting with the conductor layer 2 the green LED chip (G) which consists of an ingredient of for example, a GaP system, and the red LED chip (R) which consists of an ingredient of a GaAs system through the electroconductive glue 55, such as a silver paste and solder, on the same field. 3 surrounded the whole LED chip, is a covering member which forms the mold cavity used as 1 pixel, and is more nearly usually than ingredients, such as resin and a ceramic, made. A dispersing agent may be added in the resin mold 4 in order for 4 to be resin mold which is poured in into a mold cavity and closes an LED chip and to perform uniform color mixture. In addition, there is also a display which did not form the covering member 3 but carried out the mold of the LED chip by direct resin.

[0005] Although only the display of multicolor which consists of red LED as shown in drawing 5 , and green LED was realized since there was no blue LED chip which has sufficient luminous intensity for the conventional LED display, these people announce blue LED with a luminous intensity of 1 cds or more which is equal to the luminous intensity of red LED, and full color-ization of a display of them has been attained late in November, last year. It comes to carry out the laminating of the gallium nitride system compound semiconductor (InXAlYGa1-X-YN, 0<=X<=1, 0<=Y<=1) on silicon on sapphire, and the blue LED has a luminescence peak in about 450nm - 480nm.

[0006]

[Problem(s) to be Solved by the Invention] When the blue LED chip which consists of this gallium nitride system compound semiconductor is added and a

three-primary-colors ****** full color LED display is realized, in order to raise the brightness of a display, it is necessary to employ the property of a gallium nitride system compound semiconductor efficiently as much as possible. Since a laminating is carried out on an insulating substrate called sapphire with the permeability of a wavelength region 500nm or less sufficient transparently and colorlessly [especially a gallium nitride system compound semiconductor], if the external quantum efficiency of blue LED is gathered using this characteristic property, the improvement in brightness of the further full color display is expected.

[0007] Moreover, as shown in drawing 5 , when the LED chip with which the luminescent color differs is laid on the same field, there is a fault in which a part of luminescence of the LED chip of short wavelength will be absorbed by the LED ingredient of long wavelength from the difference in the bandgap energy of the ingredient which constitutes an LED chip. For example, a part of luminescence of the green LED chip which consists of an ingredient of a GaP system is absorbed by the red LED chip which consists of an ingredient of a GaAs system. However, since green luminescence has good visibility, even if a part of luminescence is absorbed by red LED, it hardly influences the brightness of a display. Therefore, in the former, the height of the light-emitting part of an LED chip hardly became a problem. In addition, in drawing 5 , B1 and R1 show the location of the light-emitting part of each LED chip.

[0008] However, if the blue LED chip which consists of a gallium nitride system compound semiconductor is laid on the same field together with the green LED chip which consists of the conventional ingredient, and a red LED chip, luminescence of a blue LED chip will be absorbed by green LED and red LED both ingredients. That is, the semiconductor material with bandgap energy smaller than a gallium nitride system compound semiconductor (3.4eV) absorbs luminescence of a gallium nitride system compound semiconductor. It is more desirable to avoid absorption if possible, since especially the wavelength of 500nm or less has bad visibility.

[0009] Therefore, this invention is accomplished in view of such a situation, and in realizing the full color LED display using the blue LED chip which consists of a gallium nitride system compound semiconductor, the place made into the purpose is to gather the external quantum efficiency of a blue LED chip, and raise the brightness of a LED display.

[0010]

[Means for Solving the Problem] Previously, we faced laying in a leadframe the blue LED chip which consists of a gallium nitride system compound semiconductor

in Japanese Patent Application No. No. 263783 [five to], and showed the technique which uses transparent insulating adhesives. Furthermore, this technique was applied to the three-primary-colors ****** full color display, luminescence of blue LED which becomes in the first place from a gallium nitride system compound semiconductor was reflected as much as possible within the mold cavity, external quantum efficiency was raised, and it found out that said problem was solvable by carrying out luminescence of blue LED to the second that other ingredients are hard to be absorbed. At least the LED display of this invention on the printed circuit board by which the conductor layer was formed in the front face Namely, a blue LED chip, In the LED display with which the green LED chip and the red LED chip were laid, the mold of these whole LED chip was carried out, and 1 pixel was constituted Said blue LED chip consists of a gallium nitride system compound semiconductor LED chip with which the laminating of the gallium nitride system compound semiconductor was carried out on silicon on sapphire. It is characterized by furthermore the silicon on sapphire and said printed circuit board of said gallium nitride system compound semiconductor chip having pasted up through transparence or white insulating adhesives.

[0011]

[Function] As transparent insulating adhesives on which the silicon on sapphire and the printed circuit board of blue LED are pasted up, the macromolecule adhesives of an epoxy resin system, a urea resin system, an acrylic resin system, and a silicon resin system, low melting glass, etc. can be used, for example, and what mixed the insulating white filler to said macromolecule adhesives, low melting glass, etc. can be used for white insulating adhesives. However, in this invention, if transparence does not necessarily mean colorless transparence and luminescence of blue LED is penetrated, what is colored and serves as transparence is meant. By making these adhesives transparent, blue luminescence which penetrates silicon on sapphire can be made to be able to penetrate to a printed circuit board, and can be reflected in respect of a printed circuit board. Moreover, if white, since blue luminescence which penetrates silicon on sapphire is reflected on the surface of adhesives and it can return to a luminescence observation side side, the external quantum efficiency of a blue LED chip improves.

[0012] Moreover, when the insulating white filler (bulking agent) whose reflection factor in a 360nm - 500nm wavelength region is 60% or more preferably is mixed in said insulating adhesives and it considers as white, the reflection factor of blue luminescence can be further enlarged on an adhesives front face. If fewer than 60%, reflecting [of blue glow] will become inadequate.

[0013] As a white filler whose reflection factor is said range, white powder, such as an aluminum oxide, titanium oxide, magnesium oxide, and a barium sulfate, can be used, for example. Moreover, since the viscosity of insulating adhesives can be adjusted by mixing these whites filler, it is very convenient in case the height of blue LED described later is adjusted.

[0014] Moreover, if the reflection factor in the 360nm - 500nm wavelength region of the printed circuit board side in which said blue LED chip is laid is 60% or more, when said insulating adhesives are transparent, the reflection factor of blue luminescence can be further enlarged in respect of a printed circuit board.

[0015] It is realizable for a means by which the reflection factor of a printed circuit board side can be adjusted to said range, by vapor-depositing or plating conductive ingredients, such as aluminum, nickel, Ag, and Pt, to the position which lays blue LED. Moreover, said white filler may be mixed with a paste and you may print to a position.

[0016] If the height of the light-emitting part of said blue LED chip is adjusted by the thickness of transparence, white insulating adhesives, the transparent insulating adhesives that the reflection factor used for the high printed circuit board, or the insulating adhesives of the white containing a filler and is adjusted to the location [at least] higher than the light-emitting part of a red LED chip further again, since the opportunity for luminescence of a blue LED chip to be absorbed by other ingredients decreases, the external quantum efficiency of blue LED will improve. That is, absorption of luminescence of blue LED can be prevented by thickening thickness of insulating adhesives and making the height of the light-emitting part of a blue LED chip higher than the height of the light-emitting part of the LED chip which consists of an ingredient which has bandgap energy smaller than a gallium nitride system compound semiconductor.

[0017] Insulating adhesives have the advantage that the viscosity can be adjusted freely, by mixing the property of the component itself, or a filler. the ingredient which penetrates luminescence of blue LED to a filler, or the ingredient to reflect -- although which ingredient may be used, it is the ingredient which reflects luminescence of blue LED preferably as mentioned above, and the white powder which has 60% or more of reflection factor in the wavelength region the reflection factor of whose is 360nm - 500nm is used.

[0018] Furthermore, although it is common in all cases, when the filler mixed in adhesives and adhesives is insulation, even if adhesives contact a green LED chip and a red LED chip, there is no fear of short-circuiting between chips. Since there is no fear of short-circuiting electrically between chips further again, if a blue LED

chip can be laid almost horizontally, it is possible by increasing the amount of adhesives to make the height high simply.

[0019]

[Example] Hereafter, the LED display of this application is explained in full detail, referring to a drawing. Drawing 1 is the top view showing one mold cavity of the LED display of one example of this application, drawing 2 is the type section Fig. showing the structure at the time of an alternate long and short dash line cutting the display of drawing 1 , drawing 3 is the type section Fig. expanding and showing the part of the blue LED chip of drawing 2 , and all the same signs show the same member in drawing.

[0020] The blue LED chip B with which one mold cavity carries out the laminating of the ingredient of a GaN system on silicon on sapphire, and this display changes The green LED chip G which carries out the laminating of the ingredient of a GaP system, and changes on a GaP substrate Consisting of a red LED chip R which carries out the laminating of the ingredient of a GaAs system, and changes on a GaAs substrate, the luminescence wavelength of the blue LED chip B is [the luminescence wavelength of about 550nm and a red LED chip of about 460nm and the luminescence wavelength of the green LED chip G] about 660nm. Each LED chips B, G, and R which emit light to these three primary colors as shown in drawing 1 are laid in the shape of a straight line for example, on the printed circuit board 1 in which the conductor layer 2 which consists of Au was formed.

[0021] Furthermore, from the electrode of each LED, wire bonding is given to the conductor layer 2, these LED chip is surrounded as it is also at the covering member 3, and one mold cavity is formed. Color mixture of the luminescence of each LED is carried out within this mold cavity. While making the inside of the covering member 3 reflect luminescence of an LED chip in a luminescence observation side side and raising the brightness of a LED display, the reflecting mirror which is the purpose which performs color mixture of the luminescent color within a mold cavity, for example, spreads in a radial is formed. It is one of the means by which it is above desirable when raising the brightness of a display that vapor-deposit an ingredient with the high reflection factor of aluminum, nickel, etc. to this reflecting mirror, or the white matter with the high reflection factor of the light applies.

[0022] Next, since the substrate of the green LED chip G and the red LED chip R is all a conductive ingredient as shown in drawing 2 , direct continuation of a substrate and the conductor layer 2 is carried out by the electroconductive glue 55, such as solder. On the other hand, the blue LED chip B with which the laminating

of the ingredient of a GaN system was carried out on silicon on sapphire was laid on the printed circuit board 1 in which the conductor layer 2 is not formed, and a printed circuit board 1 and silicon on sapphire are pasted up with the insulating adhesives 5 which consist of a transparent epoxy resin. Moreover, it is adjusted by the thickness of the insulating adhesives 5 so that the height of the light-emitting part B1 of the blue LED chip B may become higher than the height R1 of the light-emitting part of the red LED chip R, and the height G1 of the light-emitting part of the green LED chip G. Furthermore, alumina impalpable powder is mixed by insulating adhesives as a filler 6, and let insulating adhesives be white with this alumina impalpable powder. 4 is mold which closes an LED chip and resin, glass, etc. are used. In addition, especially the wire to which the electrode and the conductor layer 2 of each LED were connected in drawing 2 is not shown.

[0023] Drawing 3 is drawing expanding and showing the installation part of this blue LED, and the arrow of this drawing explains the locus of the light which came out of the light-emitting part of the blue LED chip B. As shown in this drawing, blue luminescence penetrates silicon on sapphire and reflects it on the front face of the insulating adhesives 5 containing the white filler 6 with a high reflection factor. Moreover, since the light which comes out to the perimeter of a light-emitting part does not have next the ingredient which absorbs the light, either, the opportunity absorbed decreases and its external quantum efficiency of a blue LED chip improves.

[0024] Moreover, drawing 4 is the type section Fig. showing the structure of the LED display by other examples of this application, like drawing 3 , expands an installation part and shows the blue LED chip. The place where this display differs from drawing 1 - drawing 3 is using the insulating adhesives 5 on which the silicon on sapphire and the printed circuit board of blue LED are pasted up as the transparent adhesives which do not contain a filler, vapor-depositing aluminum further to the 1st page of the printed circuit board just under silicon on sapphire, and forming the reflecting layer 7 with a high reflection factor. Thus, if it is the high glossy surface or white side of a reflection factor as a reflecting layer 7 in the printed circuit board side which pastes up silicon on sapphire, since blue glow can be efficiently reflected like drawing 3 , the external quantum efficiency of blue LED improves.

[0025]

[Effect of the Invention] since the LED display of this invention makes blue luminescence reflect or penetrate with the adhesives of blue LED which has silicon on sapphire as explained above -- blue luminescence -- loss -- it is taken out outside

few. Moreover, since blue luminescence is adjusted to the location which cannot be easily absorbed by other LED ingredients by the thickness of adhesives, there is little loss of blue luminescence. Since it will completely be electrically uninfluential even if the adhesives contact other LED ingredients, since adhesives are furthermore also insulation, it excels also in dependability. Moreover, even if black in the front face of the covering member 3 by the side of a luminescence observation side, it is good in order to improve contrast. Thus, since luminescence of blue LED using a gallium nitride system compound semiconductor can be taken out effectively according to the LED display of this invention, the brightness of a display can be raised and the utility value on the industry is large.

[Brief Description of the Drawings]

[Drawing 1] The top view showing the structure of one mold cavity of the LED display of one example of this application.

[Drawing 2] The type section Fig. showing the structure at the time of an alternate long and short dash line cutting the display of drawing 1 .

[Drawing 3] The type section Fig. expanding and showing the installation part of the blue LED chip of drawing 2 .

[Drawing 4] The expansion type section Fig. showing the structure of the LED display by other examples of this application.

[Drawing 5] The type section Fig. showing the structure of one mold cavity of the conventional LED display.

[Description of Notations]

1 .... Printed circuit board

2 .... Conductor layer

3 .... Covering member

4 .... Resin mold

5 .... Insulating adhesives

6 .... Filler

7 .... Reflecting layer